Department of Resources Recycling and Recovery

SCOPE OF WORK
Large-Scale Measurement of Internal and Interface Shear Strength of Tire-Derived Aggregate

I. INTRODUCTION/OBJECTIVES

CalRecycle has been working for more than 13 years to develop Tire-Derived Aggregate (TDA) technology and promote the use of TDA in civil engineering applications in California. During that time CalRecycle has designed and constructed numerous successful TDA projects. To complete the designs for these projects, it was important to determine the material properties for TDA. One of the most important TDA material properties is shear strength, as it is critical in the design of the light-weight fill applications (i.e., landslide repair and retaining walls).

Shear strength is typically determined through standard soil testing procedures. However, due to the large particle size of TDA (3 to 12 inches), standard soil testing apparatus cannot accommodate TDA. As a result, current designs are based on very conservative estimates of shear strength (essentially zero), which we know is likely not the case.

So the purpose of this study is to fabricate a testing apparatus that can accommodate the larger TDA particle size. This will utilize test methods that more accurately replicate conditions where TDA is placed in actual field projects, which will ultimately provide more accurate shear strength data.

II. WORK TO BE PERFORMED

The objective of the proposed research is to obtain high quality measurements of the internal and interface shear strength of Type A and Type B TDA materials and to report corresponding shear strength parameters that are suitable for civil engineering applications. Interface strengths will be measured for Type A and Type B TDA against a woven geotextile or other material(s) as determined by CalRecycle staff.

Shear strength measurements will be obtained using a large direct shear box that will be custom-designed and constructed at UCSD for the project. Direct shear tests will be conducted using this equipment to obtain high quality measurements of TDA internal and interface shear strengths.

III. TASKS IDENTIFIED

The research program will consist of the following four tasks:

Task 1: Shear Box Design and Construction

Construct a new direct shear testing device that is appropriately designed to accurately measure the shear strength of the larger TDA material. For example, the device shown in Figure 1 is a large-scale direct shear machine currently operating in the UCSD geotechnical engineering laboratory that is used to measure shear strength for typical soil samples used in geosynthetic and landfill liner systems. The test chamber for the device shown measures 42 × 12 × 12 inches but is too small for Type B TDA material. Therefore, a new and larger direct shear box is needed for the proposed research.

Figure 1. Dynamic direct shear machine for geosynthetic and landfill liner systems (Fox et al. 2006).

As currently proposed, the design concept for the new direct shear box is shown in Figure 2. The device will generally consist of a split box with a top section that travels over the bottom section. The TDA specimen is placed inside the box and is sheared as a result of the relative movement of the top and bottom sections. A vertical force (N) will be applied over the top surface of the specimen. A shear force (S) will be applied to the side of the top box. The new direct shear box will have the following features:

- Large specimen size: 6 × 3 × 3 ft. (minimum)
- Large shear displacement: 2 ft. (minimum)
- Maximum normal stress = 2400 psf (minimum)
- Transverse grips on top and bottom shearing surfaces to improve data quality
- Capability for displacement-controlled loading to measure post-peak strength response
- Measurement of horizontal displacement during shear

- Measurement of vertical displacement (i.e., specimen volume change) during shear
- Capability to conduct internal and interface shear tests

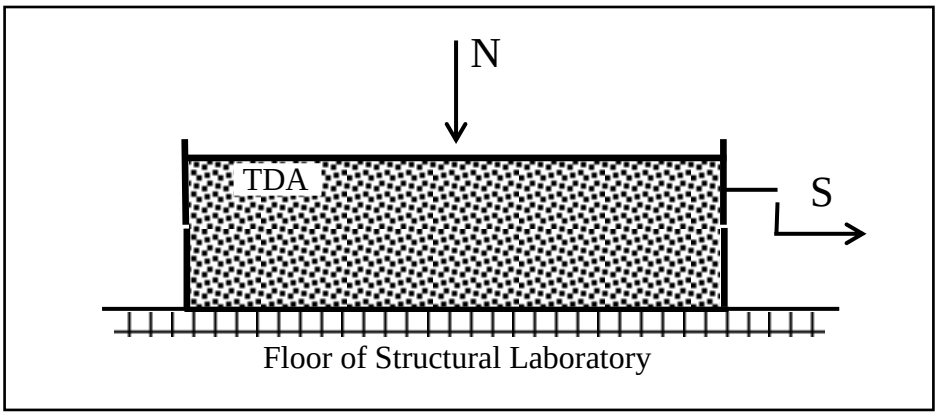

Figure 2 Concept for design of large direct shear box for TDA strength testing.

The dimensions of the TDA shear specimen are not known at present due to uncertainties with the cost of machine design and construction; however the minimum size will be 6 × 3 × 3 ft. with the longer dimension running in the direction of shear. If cost permits, a larger shear box (e.g., 8 ft. long) will be constructed to permit larger shear displacements (e.g., 2.5 to 3 ft.). Interface shear tests will be conducted by placing a concrete block in the bottom half of the box for support of the desired interface. The rate of shearing will likely be 0.01 in/sec, giving a total shearing time of approximately 1 hr for each test. Final box design specifications and budget will be discussed with, and approved by CalRecycle staff prior to construction and testing.

Task 2: Experimental Program

The variables for the experimental program are expected to be:

- TDA material: Type A, Type B
- Test type: internal shear, interface shear
- Interface materials: woven geotextile, concrete and soil
- Normal stress levels: 150, 300, 600, 1200, 2400 psf

A full testing matrix for the above variables gives approximately 30 total shear tests, which is a reasonable target for the proposed testing program. Each test will be conducted to large displacement (2 ft. minimum) to yield both peak and large displacement shear strengths. The final experimental program will be approved by CalRecycle staff before testing begins.

Task 3: Data Analysis

Raw data from the experimental program will consist of shear stress vs. shear displacement for each test specimen, which will then be used to obtain peak and large displacement shear strengths. Peak and large displacement failure envelopes for each

test configuration will be constructed using these data. Depending on the data, linear and nonlinear models, and corresponding shear strength parameters, will be used to characterize these failure envelopes. Vertical displacement data will also be analyzed for each specimen and will provide information regarding volume change characteristics for each test configuration.

Task 4: Final Project Report

The final report for the project will include test procedures, test data, analyses, and results. Results will include measured failure envelopes and associated strength parameters and volume change data for internal and interface shear strengths of Type A and Type B TDA materials.

IV. CONTRACT/TASK TIME FRAME

I. Table 3. Project Work Schedule

Task	Months from Start of Project											
	1	2	3	4	5	6	7	8	9	10	11	12
Task 1 – Shear Box Design and Const.	—	—	—									
Task 2 – Experimental Program				—	—	—	—	—	—	—	—	
Task 3 – Data Analysis									—	—	—	
Task 4 – Final Project Report												—

V. COPYRIGHT PROVISION

The Contractor shall assign to the Department of Resources Recycling and Recovery (CalRecycle) any and all rights, title and interests to any copyrightable material or trademarkable material created or developed in whole or in any part as a result of this Agreement, including the right to register for copyright or trademark of such materials. The Contractor shall require that its subcontractors agree that all such materials shall be the property of the CalRecycle. Such title will include exclusive copyrights and trademarks in the name of the CalRecycle.

VI. CALIFORNIA WASTE TIRES

Unless otherwise provided for in this Scope of Work, in the event the contractor and/or subcontractor(s) purchases waste tires or waste-tire derived products for the performance of this Scope of Work, only California waste tires and California waste tire-derived products shall be used. As a condition of payment under the agreement, the contractor shall be required to provide documentation substantiating the source of

the tire materials used during the performance of this Scope of Work to the contract manager.

VII. WASTE REDUCTION AND RECYCLED-CONTENT PRODUCT PROCUREMENT

In the performance of this Agreement, Contractor shall use recycled content, used or reusable products, and practice other waste reduction measures where feasible and appropriate.

Recycled Content Products: All products purchased and charged/billed to the CalRecycle to fulfill the requirements of this contract shall be Recycled Content Products (RCPs), or used (reused, remanufactured, refurbished) products. All RCPs purchased or charged/billed to the CalRecycle to fulfill the requirements of the contract shall have both the total recycled-content (TRC) and the postconsumer content (PC) clearly identified on the products. Specific requirements for the aforementioned purchases and identification are discussed in the Terms and Conditions of the Contractual Agreement under Recycled-Content Product Purchasing and Certification.

The Contractor should, at a minimum, ensure that the following issues are addressed, as applicable to the services provided:

A. WRITTEN DOCUMENT PROVISION

All documents and/or reports drafted for publication by or for CalRecycle in accordance with this contract shall adhere to CalRecycle's *Guidelines For Preparing CalRecycle Reports (available upon request)* and shall be reviewed by the CalRecycle's Contract Manager in consultation with one of CalRecycle's editors.

In addition, these documents and/or reports shall be printed double-sided on one hundred percent (100%) recycled-content paper. Specific pages containing full-color photographs or other ink-intensive graphics may be printed on photographic paper. The paper should identify the postconsumer recycled content of the paper (i.e., "printed on 100% postconsumer paper").
When applicable, the contractor shall provide the contract manager with an electronic copy of the document and/or report for the Board's uses.

To the greatest extent possible, soy ink instead of petroleum-based inks should be used to print all documents